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THE RTNS-II FUSION-NEUTRON FACILITY FOR MATERIAL--DAMAGE STUDIES

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THE RTNS-II FUSION-NEUTRON FACILITY FOR MATERIAL-DAMAGE STUDIES*

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1. Introduction

The Rotating Target Neutron Source-II (RTNS-II) is operated by Lawrence Livermore National Laboratory (LLNL) for the U.S. (DOE) and Japan (Monbusho). Joint support and utilization of the facility by Japan and the U.S. has been in effect for nearly 1 1/2 years. Irradiations, using the fusion neutrons produced at RTNS-II, are done in support of the fusion energy programs of the U.S. and Japan. In addition, "add-on" non-fusion related irradiations can and have been done at RTNS-II. For more general information regarding the RTNS-II facility, see Ref. 1.

2. Neutron Sources

RTNS-II has two identical accelerator-based neutron sources (designated left and right). The first of these (left) began producing neutrons in November 1978. The second neutron source was activated and first produced neutrons in June 1983, largely as a result of the increased funding available from the joint agreement. The 14-MeV fusion neutrons are produced using the $^3H(d,n)^4He$ reaction at deuteron energies between 360 and 400 keV. Each neutron source consists of three basic components. These are: 1. ion source, 2. high voltage accelerator, and 3. rotating target system.

2.1. Ion Source

The ion source used presently at RTNS-II is shown in Fig. 1. This is a multiple-aperture (MATS-III) reflex-arc type ion source as generally described by Osher [2]. The ion source used presently, however, is a seven-aperture version rather than 17 or 63 apertures previously used. The beam is extracted at 25 kV and analyzed by a 90^0 magnet to select the atomix D^+ species for injection into the acceleration tube. Nominal characteristics for the RTNS-II ion source are given in Table 1.

Table I

Nominal RTNS-II Ion Source Characteristics

Filament Current (Oxide type)	20 A
ARC current/voltage	35 A
Gas flow (D_2)	∿ 15 atm cc/min
Extraction voltage/current	25 kV/350 ma
D^+ Fraction	55-65%
D^+ Analyzed beam	110 mA

With these parameters, approximately 80-85 mA could be delivered to the target. We have recently installed higher current arc power supplies which have increased the beam on target up to as high as 110 mA. In addition, extraction power supplies with 35-kV capability will be installed in the near future. This is expected to further increase beam currents available. Among other items which remain to be investigated are extraction aperture size, shape and number as well as electrode gapping.

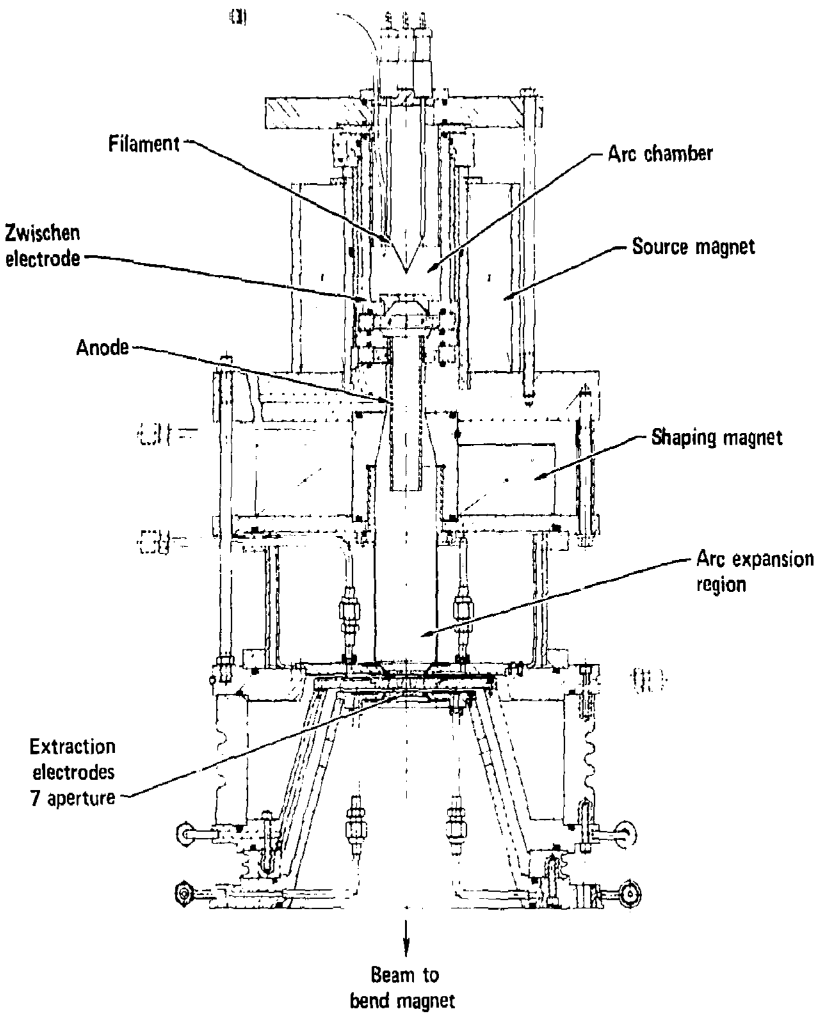

Figure 1. RTNS-II Ion Source. It is a seven-aperture version of the MATS-III source. See Ref. 2.

2.2. High Voltage Accelerator

The 25-kV D^+ beam from the ion source is accelerated to 360-400 keV by a Cockcroft-Walton type accelerator. The high voltage power supply and terminal were purchased from Emil Haefely & Co. It is air-insulated and has 400-kV to 300 mA capability. The acceleration column was designed and manufactured at LLNL. The acceleration column on the left neutron source has been in use since the beginning of operations. During this time, 4.5×10^5 mA-hr (1.6 MC) of beam has been accelerated to the target. Details of the design for the present acceleration column are given elsewhere [3,4]. Despite a considerable darkening of the ceramic sections by x-radiation and some spark tracking, the column continues to function reasonably well. External sparking occurs, however, at regular intervals at the higher voltages. To alleviate this problem, a redesign of the acceleration column was undertaken. The aim was to preserve the beam-optic characteristics while improving internal shielding of the ceramic sections. The entrance portion of the old and new acceleration columns are shown in Fig. 2. This illustrates the difference in electrode shielding. Further details on the redesign can be found in Ref. 5. The new design column is now under fabrication.

2.3 The Rotating Target System

The tritium target used at RTNS-II consists of a titanium-tritide layer on copper alloy substrates. The substrates are formed in the shape of a spherical segment. The nominal thickness of the titanium-tritide layer is 10 m while the substrate thickness is 1.5 mm. The substrates are either 23 or 50 cm in diameter and consist of two layers with photo-chemically etched water cooling passages between the layers. The two layers are formed either by diffusion bonding or electroforming. During operation, the substrates are cooled by $4^{o}C$, 2.4 MPa water and rotated at $\sim$4000 rpm to dissipate the heating due to the beam ($\sim$40 kW/cm^2).

A schematic of the air-levitated, differentially pumped vacuum seal is shown in Fig. 3. Rotation is provided by an air-driven turbine as shown. In addition, the target is oscillated as indicated to utilize the complete titanium-tritide layer. The nominal tritium contents are 4.4×10^7 and 2.0×10^8 MBq for the 23- and 50-cm substrates, respectively. The corresponding areas are 300 and 1545 cm^2. For more details concerning the tritium target system, see Refs. 6, 7, and 8.

Target performance can be best illustrated by giving the parameters of the equation

$$Y = A_1(1-e^{-A_2 \cdot X}) \quad (1)$$

where

$$Y = \text{total neutrons } (10^{18} n) \quad (2)$$

$$X = \text{incident neutrons } (10^{23} d^+) \quad (3)$$

and A_1 and A_2 are constants determined by a least-squares fitting procedure. These are given in Table 2 for both sizes of targets.

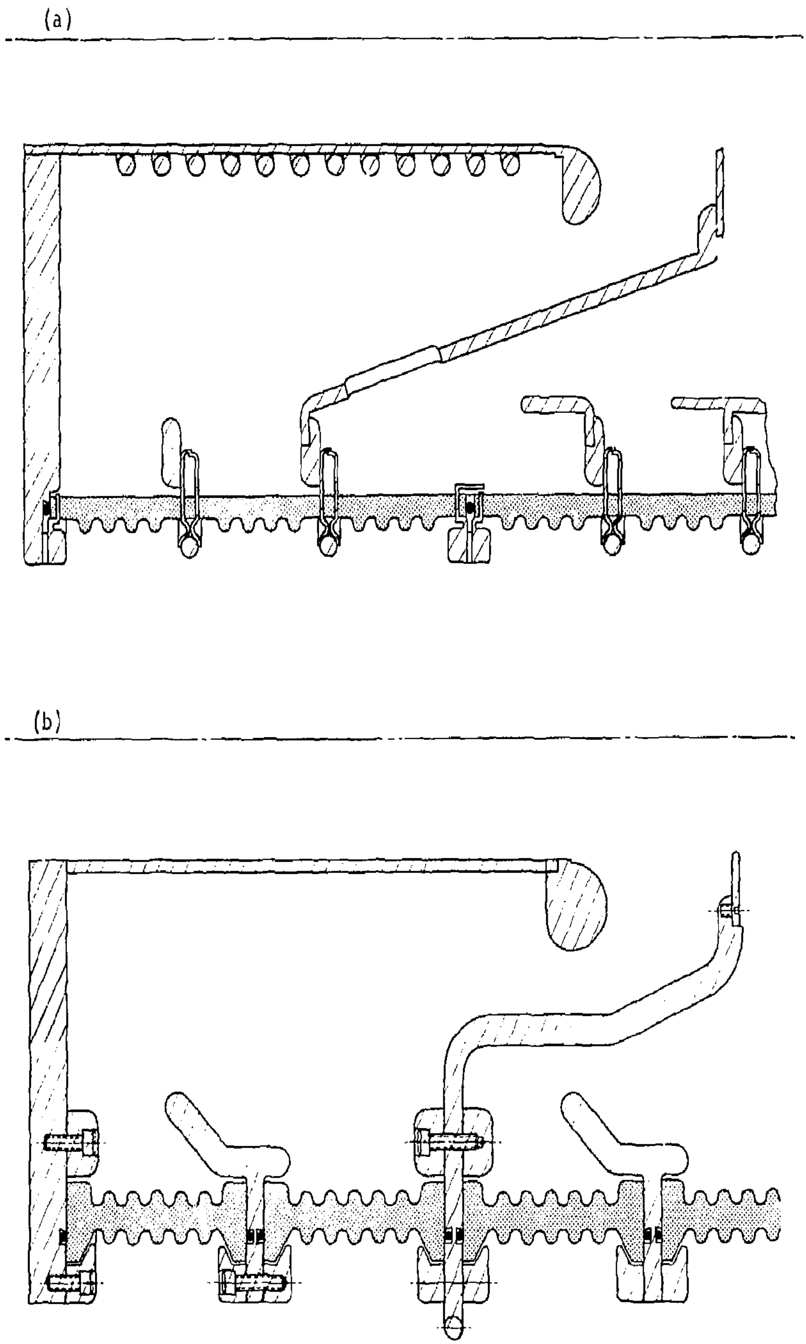

Figure 2. (a) The entrance section of the *original RTNS-II* accelerator. (b) The entrance section of the new RTNS-II accelerator column. Note the heavier ceramic shielding.

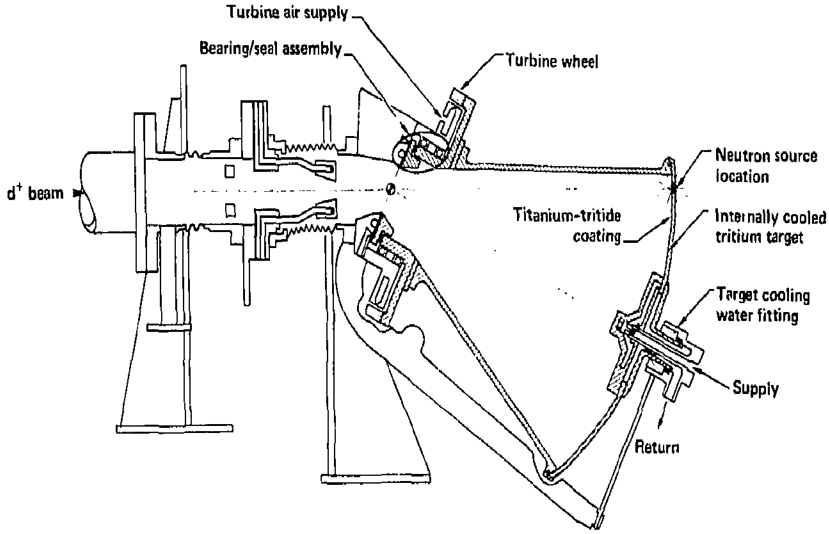

Figure 3. A schematic drawing of the rotating target assembly. The shaded parts rotate at ∿4000 rpm during operation.

Table 2

Tritium Target Parameters

	50-cm	23-cm
Average target depletion rate ($10^{-24}/d^+$)	1.5 ± .3	10.0 ± 3.2
Average initial yield (10^{-5}n/d^+)	3.9 ± .2	3.3 ± .4
Average total incident d^+($10^{23}d^+$)	3.7	1.0

3. Experimental Program

The primary experimental program to the present time has been devoted almost entirely to the fusion energy program. In fact, over 80% of the primary plus "add-on" irradiations have involved fusion materials and/or equipment. The remaining irradiations for nuclear cross section measurements, biological samples and others have been primarily of the "add-on" category. U.S. users of the facility have come primarily from DOE laboratories with fewer from universities and industry. Foreign users have come almost entirely from Japan and constitute about 40% of users to date.

Much of the experimental program has been devoted to fission-fusion correlation studies in an attempt to understand the dependence of radiation effects on the primary recoil energy. Pure metals, alloys, and insulators have been irradiated for this purpose. The changes in these materials, electrical, mechanical and optical properties, have been studied.

Another area which has received considerable attention is the effect of 14-MeV neutrons on superconducting magnet materials. More specifically, irradiations have been done on superconductors, the copper stabilizer, and organic insulators.

Another area of investigation is the effect of the 14-MeV neutron environment on various diagnostic equipment such as fiber optics, photomultipliers and other electronic components.

All of these areas of investigation are discussed in much greater detail in the annual report (see Ref. 9).

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